

## NEAR-UV TO NEAR-IR DISK-AVERAGED EARTH'S SPECTRA FROM MOON'S EARTHSHINE OBSERVATIONS

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**Abstract.** We discuss a series of Earthshine spectra obtained with the NTT/EMMI instrument between 320nm and 1020nm with a resolution of  $R \cong 450$  in the blue and  $R \cong 250$  in the red. These ascending and descending Moon's Earthshine spectra taken from Chile give disk-averaged spectra for two different Earth's phases. The spectra show the ozone (Huggins and Chappuis bands), oxygen and water vapour absorption bands, and also the stronger Rayleigh scattering in the blue. Removing the known telluric absorptions reveals a spectral feature around 700nm which is attributed to the vegetation stronger reflectivity in the near-IR, so-called vegetation red-edge.

### 1 Introduction

Since the first measurements of Earth disk-averaged reflectance spectra by Arnold et al. (2002) and Woolf et al. (2002), several attempts have been successful in the same spectral bandwidth (Seager et al. 2005, Montañés-Rodríguez et al. 2005). Most of these spectra show signatures of Earth atmosphere and ground vegetation.

### 2 Earth's reflectance spectra

We get four Earthshine Moon's spectra at the NTT/EMMI telescope in ESO/Chile during the nights of the 09-18-04, 05-24-04 and more recently, 05-31-05 and 06-02-05. The spectra cover the domain from 320 to 1020nm with a gap of 20nm between 510 and 530nm. The resolution is  $R \approx 450$  in the blue and  $R \approx 250$  in the red. We extracted the Earth's integrated reflectance spectra by correcting these spectra

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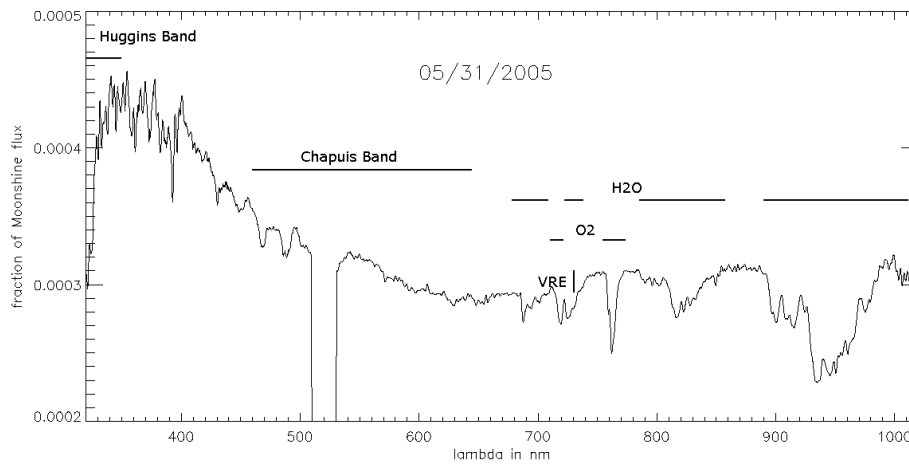
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from the Moon reflectance, the Sun spectra and the atmosphere transmittance. We also take into account the changing colour of the integrated Moon versus its observation phase (Lane & Irvine 1973).

We can identify on each reflectance spectrum the absorption bands of  $O_2$ ,  $O_3$  and  $H_2O$ . The Rayleigh scattering is well visible, as well as the strong absorption of ozone Huggins band from 320nm to 350nm (Fig. 1).

It is known that the vegetation has a stronger reflectivity in the near IR above 700nm with respect to the visible. To measure it, we correct our reflectance spectra from the atmospheric absorption lines and the Rayleigh scattering to get Earth's ground reflectance. By comparing the flux in two spectral domains bracketing the 700nm rise, we measure the Vegetation Red-Edge (VRE) relative to the continuum. We measure  $VRE \approx 10\%$  when the Earth facing the Moon shows Africa and Europe, and  $VRE = 3\%$  with the Pacific Ocean and a small part of North America. This demonstrates how Earth's phase influences the detectivity of the vegetation.



**Fig. 1.** Earth reflectance spectra for the West Africa and part of the Atlantic Ocean.

## References

- Arnold, L., Gillet, S., Lardi re, O., Riaud, P., Schneider, J., 2002, A&A, 352, 231-237  
 Lane, A. P. and Irvine, W. M., 1973, Astronomical Journal, 78, 267  
 Monta es-Rodr guez, P., Pall , E., Goode, P. R., Hickey, J., Koonin, S. E., 2005, ApJ, 629, 1175-1182  
 Seager, S., Turner, E. L., Schafer, J., Ford, E. B., 2005, Astrobiology, 5, 372-390  
 Woolf, N. J., Smith, P. S., Traub, W. A., Jucks, K. W., 2002, ApJ, 574, 430-433